PROBABILISTIC ANALYSIS OF 2-GRID ION OPTICS FAILURE MECHANISMS

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Because of their high specific impulse and high efficiency, ion engines offer significant savings in spacecraft mass and, in certain cases, trip time. They arc being, considered for usc in a number of earth orbital applications including stationkeeping, orbit-raising and repositioning as well as in planetary missions. However, because they are low thrust devices, very long periods of operat ion are required to achieve useful total impulses. During a typical mission an ion engine would be required to operate reliabl y for thousands of hours. The primary failure mechanisms identified in two-grid ion systems arc structural failure caused by sputter erosion of the downstream grid by ion impingement and shorting of the electrodes by flakes of material sputtered from the accelerator grid onto the screen grid. A description of the physical process involved in these two failure mechanisms, a general approach to assessing service life probabilist i call y, and an application of this approach to ion engine optics will be presented in the paper.

The analysis method employs models of the ion optics failure mechanisms and available test data in a statistical framework in which uncertaint ies about the governing parameters and model accuracy arc quantitatively treated. The uncertaint y in input parameters such as engine operating condit ions, material properties and geometry is specified by appropriate probability distributions. Model accuracy factors arc also specified probabilist ically. Values are then sampled from these distributions and used in the failure models in a Monte Carlo simulation to generate distributions of engine service life.

initial modeling of ion engine accelerator grid structural failure using this technique revealed that the failure risk is driven by lack of knowledge about certain input parameters. 'l'his paper will present refined estimates of structural failure probability made possible by add it ional failure mechanism modeling and experiments. Shorting of the grids by sputter-deposited flakes may actually occur before complete structural failure of the accelerator grid. A preliminary analysis of this failure mechanism based on models of the sputter erosion rote, material deposition rate and the probability y of flake formation will also be presented.